the equation of a hyperbola whose semi-transverse axis is ·1025 centimetres, and semi-conjugate axis 6·8623 C.G.S. units. From the above equation we infer that—

$$R = 66{\cdot}94 \sqrt{\left\{1 + {\cdot}205 \frac{1}{s}\right\}}$$

where R denotes the electrostatic force; from which it is evident that as s becomes smaller R becomes greater. A similar curve was obtained when hydrogen was substituted for air.

When the disks were heated before taking the sparks, the curve obtained satisfies the equation—

$$V = 87{\cdot}04s - 19{\cdot}56s^2,$$

a parabola, from which we deduce—

$$R = 87{\cdot}04 - 19{\cdot}56s.$$

It was found that when the capacity of the charged conductor was changed, the difference of potential required to produce a spark remained constant.

When the discharge was continued so as to keep the spot of light at a fixed deflection, the reading was always less than for the corresponding single discharge, but the curves were similar.

Readings were taken of the difference of potential required to produce a ·5 centimetre spark through air at different pressures from the atmospheric to 20 mm. They give—

$$V = {\cdot}0458 \sqrt{\{p^2 + 203p\}}$$

where p denotes the pressure in millimetres of mercury.

The electric strengths of several gases were determined by comparing the differences of potential required to pass a ·5 centimetre spark through the gas at the atmospheric pressure.

Dielectric.	Electric Strength.		
	Macfarlane.	De la Rue and Müller.	Faraday.
Air	1	1	1
Carbonic Acid ...	·95	1·06	·91
Oxygen	·93	1	·71
Hydrogen	·63	·54	·53
Coal Gas	·93	—	·71

"Electric strength" is the term used by Prof. Clerk-Maxwell to denote the physical constant in question. I have added, for the sake of comparison, values deduced from the results of De la Rue and Müller and of Faraday, but the ratios given do not strictly give the relative electric strength, but the ratio of the lengths of spark when the difference of potential is kept constant.

The difference of potential required to produce a spark between two spherical balls is approximately proportional to the square root of the length of the spark. This we have verified up to 15 cm.

On proceeding to investigate the discharge through insulating liquids, we first took up oil of turpentine. The liquid was placed in a glass jar of 7 inches diameter and 5 inches height. A screw passing through the bottom of the jar served to fix the lower electrode, and also to afford conducting connection with the earth. We observed four modes of discharge: by means of threads of solid particles, by motion of the liquid, by a disruptive discharge, and by motion of gas bubbles. When a chain was formed the index of the electrometer behaved as if a current were passing. The discharge, when sufficiently great, broke the thread and turned into a spark. The liquid was more easily set in motion when its surface was not much higher than the upper plate. The bubbles of gas appeared to be formed by the passing of the spark. They were always attracted to the negative electrode. When the electrification was neutralised they of course adhered to the under surface of the upper disk; when the disk was electrified negatively they still adhered; when positively they were repelled so as as to remain suspended in the liquid or to adhere to the lower electrode, according to the greater or less distance between the electrodes. At a diminished pressure the bubbles produced at the upper surface were observed to effect the discharge by carrying the electricity with them to the negative electrode. The fact that it is possible to cause a shower of electrified bubbles to descend and produce a flash and sound on impinging on the lower surface appears to throw some light upon the nature of lightning balls.

Similar phenomena were observed in paraffin oil, excepting that the gas bubbles produced were generally attracted to the positive surface.

We observed the differences of potential required to pass a spark through paraffin oil and oil of turpentine between plates for distances up to ·5 cm. It was impossible to observe for greater distances, as our insulated wire allowed the charge to escape. For paraffin oil,

$$V = 750\,s - 15;$$

therefore,

$$R = 750.$$

The above has not been reduced to absolute measure. Thus R is constant in the case of the liquids, but variable in the case of the gases.

Electric Strength of Liquid Dielectrics

Air	1
Paraffin Oil (kind used for burning)	4
Oil of Turpentine	3·7

Sparks were taken between two platinum wires placed at right angles to one another. When one of the wires was heated by a voltaic current the electrometer deflection was diminished by about one-fourth of its amount.

We have also investigated the effect upon the electric spark of heating the air round the disks, the pressure being kept constant. The deflections of the electrometer for a constant spark for temperatures from 20° C. to 280° C. indicate a curve which slopes down gradually as the temperature is increased, while the deflections during cooling give a curve which is somewhat lower at the lower temperatures.

These experiments were made in Prof. Tait's laboratory, to whom we are indebted, not only for the use of apparatus, but also for ever ready advice.

SCIENTIFIC SERIALS

Annalen der Physik und Chemie, No. 10.—The loss of electricity by an insulated charged body in rarefied gas in an envelope that has conductive connection with the earth is here stated by Herr Narr to be due to two processes distinct in time and intensity, the first, one of outflow, rapid and intense, the other, one of dispersion, slow and weak. The intensity of the former increases with decreasing density of each of the gases used (CO_2 air and H), and also on substituting one gas for the other in the order just given, the density remaining constant. These differences between the gases decrease with the density, and in vacuum fal within the limits of errors of observation. In discussing these results, Herr Narr is led to regard the condensed layer of gas on the conducting system as an insulator, not as a conductor.—Dr. Holz finds that the specific magnetism of magnetic ironstone is the greatest of all magnetic substances hitherto examined. Its maximum permanent magnetism is nearly as great, and partly greater than that of steel as hard as glass. Its permanent magnetism is sooner removed in demagnetisation with the same external forces than that of steel, &c.—Dr. Strouhal enunciates the laws of a mode of sound-production not much studied hitherto, that, viz., of rapid swinging of a rod, a blade, or the like, in air, or the passage of air-currents over strong wires or sharp edges, &c.—Herr Braun contributes a long and interesting paper on the development of electricity as equivalent of chemical processes.—Herr Koch demonstrates the applicability of the method of determining coefficients of elasticity from the bending of short bars supported at the two ends, the sinking in the middle being measured by means of Newton's interference-bands, and he suggests a more thorough investigation of the elasticity of crystals, by the improved means he describes.—Some remarks on the atomic weight of antimony, with reference to Cooke's recent research, are communicated by Herr Schneider.

American Journal of Science and Arts, November.—In the opening paper Prof. Dana considers the value of some distinctive characters generally accepted in defining certain kinds of rocks, as, "older and younger," foliated or not, and porphyritic structure; showing them to be often trivial and inapplicable.—With regard to the relative agency of glaciers and sub-glacial streams in the erosion of valleys, Prof. Miles considers that the streams are of primary importance in working in advance of the ice in deepening and enlarging these valleys, and that the glaciers abrade, modify, and reduce the prominent portions left by the streams, and give them the well-known glaciated sur-

faces.—Prof. Holden describes certain cloud-shaped forms (obscuring the smaller forms of Janssen) observed on the sun's disc on September 16, and cites a like observation made by Prof. Langley, in 1873, who thinks the effect chiefly due to our own atmosphere, while disposed to admit the possibility of some obscuration in the sun itself.—A pseudomorph after anorthite, from Franklin, New Jersey, is described by Prof. Roepper; and Prof. Verrill gives an account of recent additions to marine fauna of the east coast of North America.—There is also a notice of Edison's sonorous voltameter.—Prof. Marsh's important contribution on the principal characters of American Jurassic dinosaurs has been previously referred to in these columns.

Morphologisches Jahrbuch, vol. iv., Part 3.—Studies on the innervation of the hair-bulbs of domestic animals, by R. Bormel, 70 pages, 3 plates.—On *Gloidium quadrifidum*, a new genus of Protista, by N. Sorokin.—The development of the knee-joint in man, with remarks on the joints in general, and the knee-joints of vertebrates, by A. Bernays.—The skeleton of the Alcyonaria, by G. von Koch, including a minute description of the skeleton in each genus, a general account of it, and a new systematic arrangement, 33 pages, with 2 plates.—C. Hasse continues his studies on fossil vertebræ; this part is devoted to their histology, and is illustrated by 4 plates.

Zeitschrift für wissenschaftliche Zoologie, vol. xxxi. Part 2.—Contribution on the Julidæ, by E. Voges, dealing very considerably with the tracheal system and its development. There are descriptions of many new species of Julus, Spirostreptus, and Spirobolus; 68 pages, 3 plates.—On the development of the blastoderm and the germinal layers in insects, by N. Bobretzky, with figures chiefly of *Porthesia chrysorrhœa*.—On the genus Brisinga, by H. Ludwig.—On Aspidura, a mesozoic genus of ophiurid, by Hans Pohlig.—On the structure and development of sponges, Part 5, by F. E. Schulze; another most valuable contribution, the author having now completely followed the development of *Sycandra raphanus*, 34 pages, with 2 beautiful plates.

Parts 3 and 4 in one.—On the cerebral sulci in Ungulata, by Julius Krueg; the paper deals very largely with the fœtal development of the convolutions, 50 pages, 4 plates.—Contributions to the anatomy of Ophiurans, by Hubert Ludwig, treating especially on the skeleton of arm and mouth, and the sexual organs, 50 pages, 4 plates.—On the generative organs of *Asterina gibbosa*, by Hubert Ludwig, 1 plate.—An account of the anatomy of Magelona, an interesting form, by Dr. W. C. McIntosh, of St. Andrews; translated from English for the journal, 72 pages, 10 plates.—On some cases of parasitism among Infusoria, by J. van Rees.—Brief notes on the development of Anodon, by C. Schierholz.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, December 12.—"The Magic Mirror of Japan," Part 1, by Professors W. E. Ayrton and John Perry, the Imperial College of Engineering, Japan. Communicated by William Spottiswoode, M.A., Treas. R.S., &c.

The President stated that Prof. Ayrton had agreed to give, in the Friday evening discourse on January 24, at the Royal Institution, a full account of Japanese mirrors, so that on the present occasion he understood the authors of the paper merely proposed to enter very shortly into the subject.

Prof. Ayrton commenced by remarking that mirrors in Japan held a very high position, and constituted the most prominent feature in the Japanese temples, taking the place of the cross in Roman Catholic countries, and that the principal mirror in the Imperial Palace ranked higher than even the Emperor himself. He referred to the important place the mirror held in the very limited furniture of a Japanese household; to the respect attached to it by the women, and to the fact that while the sword was considered as "the soul of the samurai" (or two-sworded class) the mirror was looked on as "the soul of the woman." He next showed experimentally the so-called magic property possessed by certain rare bronze mirrors, sold by the Chinese at about twenty times the cost of the ordinary mirrors of that country, and which consisted in these mirrors being able to reflect from their smooth polished faces the raised patterns of birds, flowers, dragons, or Chinese letters with which their backs were adorned. He stated that he had found this property to be possessed by a very small percentage of the Japanese mirrors which he had experimented on, but that its existence was quite unknown to the people of that country. The phenomenon had been known in China for centuries, and that, therefore, while he showed it experimentally to the Fellows, he did so in case there might be some there who had never seen it, in consequence of these magic mirrors being rare; but he desired it to be remembered that it was not the phenomenon itself but the explanation of it which he had the honour of bringing before them as new.

After citing all the possible ways in which this curious reflecting power could be accounted for, and referring to a number of printed notices that had at various times appeared of the magic mirror, the majority of which were accompanied with a theoretical explanation, he remarked that as the authors had apparently not made direct experiments with the mirror itself to elucidate the cause of the phenomenon, but rather to have satisfied themselves with endeavouring to find out how it could be reproduced in Europe, it was not to be wondered at that many of the suggested possible explanations were very far from the truth. Up to the present time, he believed, the idea of inequality of density of the surface of the metal mirror produced naturally in cooling, or in the supposed process of stamping, seemed to have found most favour in the West, while the belief that this variation in density arose from trickery on the part of the maker was the view entertained in China. Sir David Brewster and Sir Charles Wheatstone, on the other hand, who also thought that trickery was the explanation, believed the artifice to consist in the maker skilfully scratching on the face of the mirror, before polishing, lines exactly corresponding with the pattern on the back.

Prof. Ayrton next described what was the explanation of the phenomenon his experiments, made during the winter of 1877-78, had led him to, viz., that there existed extremely slight irregularities in the curvature of the polished surface (quite invisible to direct vision), of such a nature that the thicker parts, corresponding, of course, with the raised patterns on the back, were flatter than the remaining convex surface, so that there was less dispersion of light from the thick portion than from the thinner. He then described one of a series of diagrams illustrating various experimental arrangements of convergent and divergent beams of light which the authors had availed themselves of, and the use of which constituted, he said, the essence of the system of investigation employed by Prof. Perry and himself, and he explained that if his theory of the phenomenon was correct, then placing the screen, on which the reflection of the light from the Japanese mirror was cast, in a certain position, the phenomenon ought to *disappear*, and again putting the screen in another position, the phenomenon ought to be *inverted*; that is, instead of a bright image on a dark ground, which hitherto had alone been what has been observed by previous investigators, a dark image of the pattern on a bright ground ought to appear. This disappearance and absolute inversion of the phenomenon he said he had found to actually take place, but that he was compelled from want of time to leave the experimental exhibition of it for the Royal Institution. Various other facts, such as the necessity of holding the screen rather near, but not very near, the mirror when ordinary sunlight without lenses was employed, was, like the inversion phenomenon just referred to, shown to be explainable only on the inequality of curvature theory, and not on the inequality of density theory.

The next question that arose was how was this inequality of curvature produced? This was explained to be due to the method employed by the Japanese for making the face of the mirrors convex, which method had hitherto been quite unknown to foreigners, but which Prof. Ayrton had, after much trouble, found to consist in scratching the face while cold with a *megebo*, or "distorting rod." During the operation the mirrors became visibly concave, but, receiving a "buckle," sprung back again so as to become convex when the pressure of the rod was removed. The thicker parts of these magic mirrors yielded less under the pressure, were made therefore less concave when under the rod, and sprung back less, or became less convex, when the pressure of the rod had been removed. He then showed how this explained the fact discovered by Prof. Atkinson, of the Imperial University, Japan, in 1877, that a small scratch made on the back of a mirror with a blunt nail, although producing apparently no effect on the other side, became nevertheless visible as a bright line on the screen when a light was reflected from the mirror.

Prof. Ayrton concluded by remarking that while the Japanese knew nothing of the so-called magic phenomenon that formed the subject of the paper that evening, he had ascertained that